Biodiversity conservation: measurement and economic analysis

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The science of biodiversity conservation has come of age in Australia. The combined effect of better information on conservation priorities and improved mechanism design means that it is now possible to implement cost-effective biodiversity conservation schemes.

We outline recent advances in the development of databases, mapping tools and concepts for characterising the quality and spatial attributes (location, size, connectivity) of native vegetation and species' habitat. The conservation strategies that provide impetus for these developments are emphasised.

The paper also highlights the role of ideas from information economics in stimulating thinking about mechanism design. How the new information about biodiversity can improve the efficiency of policy mechanisms is outlined. Specific attention is given to payments for conservation services, environmental management systems, voluntary programs, and catchment-wide decision-making processes.

1 Introduction

Biodiversity is defined as *the natural diversity of all life: the sum of all our native species of flora and fauna, the genetic variation within them, their habitats, and the ecosystems of which they are an integral part* (NRE 1997a). It encompasses a large range of living things and ecosystems that are constantly evolving and adapting to environmental change (NRE 1997b).

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Biodiversity can be viewed in two ways – from a conservation significance viewpoint or from a biophysical process viewpoint. The conservation significance view focuses on the intrinsic value of Biodiversity or "what we need to do for Biodiversity". The biophysical process view focuses on the services that a balanced, viable and stable ecosystem provides or "how we benefit from biodiversity". Arguably, the policy agenda is being driven by the first - that is by a concern for the protection, enhancement and restoration of native biodiversity.

The destruction and modification of habitat, particularly through the clearance of native vegetation, is the most significant cause of biodiversity decline (SEAC 1996; Industry Commission 1998; Williams 1999). The direct consequences of clearing native vegetation for agriculture are the depletion of some native ecological communities and species. Around 63% of the Ecological Vegetation Classes (EVCs) that exist in the Victorian private land estate are classified as 'threatened with extinction', ie. more than 70% of their former extent has been lost; EVCs are formally defined classes or types of native vegetation communities (NRE in prep). Careful management of the rural landscape is essential for biodiversity conservation, as many ecological communities are now highly restricted in extent and heavily dependent on private landholders for their continued existence.

This loss of biodiversity is widely recognised as one of the most significant environmental problems facing Australia. It is now a core issue within major national programs - the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality. In a recent review of Australia's environmental performance, the OECD (1998) commented:

> Outside of protected areas, while there has been progress in conservation of natural resources (land, soil and water), progress in conservation of biodiversity (habitats and species) has been extremely limited. Much remains to be done to translate Australia's broader strategic approach and commitment to sustainability to actual <u>management</u> of natural resources that integrates ecosystem and biodiversity protection concerns in decision making and actual practice.

Addressing the problem of biodiversity loss requires some crucial information gaps to be filled. There are two such information gaps.

Consistent information is needed about the state of biodiversity in a form that can be systematically used for management decisions on many scales - site, property, landscape, regional. As part of this, the information must allow monitoring of changes in the state of biodiversity - its further loss on the one hand or its maintenance, enhancement and restoration on the other hand.

The second information gap relates to how information about the state of biodiversity, and changes in this state, can be effectively translated into action. Mechanism design in the field of biodiversity conservation is relatively new - particularly, mechanisms that use information about the state of biodiversity as their foundation. Information economics is providing the theoretical framework for these developments.

In this paper, the aim is to outline and comment on recent developments in overcoming information gaps, particularly as they relate to conservation on privately owned land.

2 Policy Context

Over the 1990s, biodiversity conservation has emerged as a major priority for Governments in Australia. Beginning with the *Flora and Fauna Guarantee Act* 1988, legislation that has a focus on ecosystems and threats to biodiversity has replaced legislation that largely emphasised individual species. All states and territories have now produced biodiversity strategies, and are moving to incorporate biodiversity in other programs as is the supra state Murray-Darling Basin Commission. Biodiversity is also a concern of regional catchment management bodies as well as local government.

Victoria's Biodiversity Strategy provides high-level policy direction for achieving biodiversity conservation goals within the context of ecological sustainability on private land. The Strategy introduces the 22 Victorian terrestrial biogeographic regions (bioregions) which cluster under the national Interim Bioregionalisation of Australia (Thackway & Creswell 1995).[2] The Biodiversity Strategy establishes five key management objectives for biodiversity management in Victoria:

- There is a reversal, across the entire landscape, of the long-term decline in the extent and quality of native vegetation, leading to a net gain with the first target being no net loss by the year 2001,
- the ecological processes and the biodiversity dependent upon terrestrial, freshwater and marine environments are maintained and, where necessary, restored,
- the present diversity of species and ecological communities and their viability is maintained or improved across each bioregion,
- there is no further preventable decline in the viability of any rare species or of any rare ecological community, and
- there is an increase in the viability of threatened species and ecological communities (NRE 1997b).

This Strategy does not stand alone, but is supported within the broader policy framework. For instance, under the environment policy *Our Natural Assets*, environmental and conservation considerations will be incorporated into all aspects of planning and government program delivery, and the Victorian Government has committed to the conservation of native vegetation on private land. The agriculture policy *World Class and Green*, in part, aims to restore the health of rivers and catchments. While the policy acknowledges that issues relating to native vegetation retention are complex and difficult and that farmers should have the flexibility to manage their land in the optimum way, the policy states that this must be balanced against the broader public interest in conserving remnant native vegetation.

Victoria's Biodiversity Strategy specifies a policy of "No net loss of native vegetation"; a principle that is further developed into a proposal for 'net gain' in *Victoria's Draft Native Vegetation Management Framework* (NRE 2000b). The draft Framework states:

> Net gain is where losses of native vegetation and habitat are reduced, minimised and more than offset by commensurate gains. The losses and gains are determined by a combined quality-quantity measure and over a specified area and period of time.

[2] The bioregions capture the pattern of ecological characteristics in the landscape, providing a natural framework for recognising and responding to biodiversity values. The bioregions tend to reflect patterns of land use and the relationships between natural resource-based activities and biodiversity assets.

> Additional outcomes are identified for biodiversity, land and water quality, and climate change amelioration. (p.6)

The loss of condition and extent of known biodiversity assets (especially fauna and ecosystems) continues to outpace any modest gains achieved through restoration. Priorities are thus in the following order:

- protect existing biodiversity assets
- enhance their condition,
- restore their former extent (regenerate, revegetate, reintroduce).

Victoria's initiatives in vegetation management are consistent with the National Framework (ANZECC 2000).

In 1987, the State Government introduced the *Planning and Environment Act* which, among others matters, controlled the rate of clearing of freehold land. Amendments to the Act have since been passed to allow relatively unhindered plantation development across most of the private land in the State. A revised framework for planning *Victoria Planning Provisions*, introduced in 1997, also governs how local government takes account of native vegetation in planning decisions. Local government is the lead authority in assessing applications to clear native vegetation.

There are important changes also at regional levels. The regional catchment strategies of Catchment Management Authorities in Victoria reflect biodiversity priorities, and each Authority has prepared a Regional Vegetation Management Plan. Biodiversity Action Planning is an initiative of the Department of Natural Resources and Environment that is designed to assist regional planning for biodiversity conservation. The objective is to translate, at the bioregional and local landscape levels, the principles and processes identified in Victoria's Biodiversity Strategy.

3 Better information about biodiversity

Developments in the policy and planning arena over the last decade have created new demands for information about biodiversity and changes in its status, both in Victoria and elsewhere in Australia. There are several key needs:

- An inventory involving the mapping of type and extent of native vegetation within each vegetation class,
- A consistent set of rules for classifying vegetation according to priority for conservation,
- A capacity to monitor change over time, and estimate historical change.

The draft Vegetation Management Framework (2000) proposes an accounting system i.e. a system capable of monitoring change, which is based on these three elements.

3.1 Inventory

Inventory of vegetation in Victoria at the level of Ecological Vegetation Class is well advanced, though some areas of the State are still to be covered. Victoria's datasets on vegetation are also consistent with the National Vegetation Information System, which stores data on Australian vegetation (type & extent), and sets technical standards for collecting and compiling data. Such information is a key input to the Natural Heritage Trust and the National Action Plan for Salinity and Water Quality.

3.2 Towards a set of rules for comparing areas of native vegetation

Parkes *et al.* (in prep) set out the requirements that the Victorian Department of Natural Resources and Environment (NRE) has for an approach to assessing native vegetation. The approach should:

- provide an objective assessment of quality, that is both reliable and repeatable,
- measure the degree of 'naturalness' as a contribution to broader conservation value assessments that set priorities for protection and investment,
- indicate the direction and amount of potential improvement for lower quality sites,
- allow comparison between different vegetation types,
- allow combination of quality and quantity assessments,
- enable calculation of net outcomes, either for individual trade-off and offset scenarios, or for measuring overall achievements of policies and programs at regional scales,
- be undertaken rapidly and by a range of natural resource managers (i.e. not just field ecologists),
- present a simple and robust message to land managers about the important components of native vegetation management.

For assessing the role of native vegetation in another context, eg. landscape stability or water cycling, a different set of objectives and an approach, hopefully complementary, might be required (Parkes *et al.* in prep).

The key to classifying and comparing different units of vegetation according to priority for conservation lies in establishing three key characteristics of the vegetation: its conservation status, its quality and the conservation status of species present.[3] Together these make up conservation significance. Consistent criteria for determining conservation significance across the state are outlined in the draft Native Vegetation Management Framework (NRE 2000). Four categories of significance are recognised for native vegetation: very high, high, medium and low. Similar rules operate for species, which are categorised as: threatened, rare, regionally significant or common (NRE 2000).

Conservation significance [4]
= conservation status of vegetation X vegetation quality
and/or
conservation status of species

This provides the basis for decisions about protecting, enhancing and restoring native vegetation and the habitat of species.

Conservation status is obtained by ranking all native vegetation types according to the extent of their depletion from pre-European coverage. Threatened vegetation types have the highest priority for protection, enhancement and restoration. Native species of plants and animals are also ranked according to national, state and bioregional conservation status.

3.3 Habitat-hectares as benchmarks for monitoring change in vegetation quality

The habitat hectare measure is "an equivalence measure of quality and quantity of native vegetation that is assessed on the basis of indicators of the vegetation's inherent condition and current viability" (NRE 2000). According to Parkes *et al.* (in prep):

> 'vegetation quality' is determined according to how the current vegetation differs from a benchmark which represents the average characteristics of a mature stand of the same vegetation type immediately prior to European settlement (ie. prior to 1750).

[3] Size of the area is an additional factor.
[4] Conservation significance can also arise if sites possess other attributes such as unique National Estate values or values as a internationally recognised site for migratory birds.

Parkes *et al.* (in prep) limit the aims of the benchmarking to providing a consistent reference point for 'naturalness' against which loss of quality and direction for improvement can be considered. Other aims such as setting a goal for restoration or making statements about the desirability or nature of pre-1750 vegetation are excluded.

The method works by defining key components of each vegetation community. Victoria is using the Ecological Vegetation Class as the basis for its system. Scoring these components can be difficult. It is necessary for experts to follow the guidelines (Parkes *et al.* in prep), and for there to be periodic checks to ensure consistency between the experts! The system is relatively well advanced for vegetation classes with a tree canopy, but not for grasslands, herblands and other treeless vegetation.

The basis for deriving a 'habitat score' for a treed vegetation community is shown in Table 1. Several components for both the condition of vegetation and its viability in the landscape are separately scored against the maximum possible weight. There are usually several criteria for judging each component (see Parkes *et al.*, in prep); these have been worked out by expert botanists.

Table 1 **Components and weightings of the habitat score.**

	Component	Max. Value
'Site Condition'	Large Trees	**0.10**
	Tree (Canopy) Cover	**0.05**
	Understorey (non-tree) strata	**0.25**
	Weediness	**0.15**
	Recruitment	**0.10**
	Organic Litter	**0.05**
	Logs	**0.05**
'Landscape Viability'	Patch Size	**0.10**
	Neighbourhood	**0.10**
	Distance to Core Area	**0.05**
	Total	**1.00**

The number of habitat hectares is derived simply by multiplying the 'habitat score' by the area of the site. Three adjacent areas each of 10 hectares in size, but with quality ranging from ‘fully natural’ to poor might be assessed as 10 habitat hectares, 5 habitat hectares and 2 habitat hectares respectively. This is the basis for determining relative priority of management actions – how much will any one action (to protect, enhance or restore native vegetation) increase the number of habitat hectares.

As Parkes *et al.* (in prep) say: “Several years ago the notion of a 'condition assessment' was considered novel and innovative. In the near future such approaches are likely to become common.”

4 Improvements in mechanism design for influencing property-level decisions

The advances in information systems for biodiversity are now being linked to the development of new mechanisms for achieving public conservation goals on private land. These advances can be broadly grouped as:

- how payments for conservation services are delivered,
- the incorporation of biodiversity standards into environmental management systems, and
- how priorities are set within voluntary programs.

In each case, the advances in knowledge are helping to prioritise sites to be protected, enhanced and restored, and are ensuring maximum result for a given effort (whether public or private effort).

4.1 Payments for conservation services

Payments to land holders for conservation management has generally taken the form of one-off grants in Australia. In other countries, payments have been more frequently linked to management agreements lasting over time. Bowers (1999) argues that management agreements are the only vehicle providing the certainty that is required when Governments seek to conserve biodiversity of high conservation significance on private land. Otherwise, first mover and moral hazard problems may lead to the loss of the asset.

In order to overcome information problems associated with negotiating individual agreements with farmers and with standard payment systems, NRE is experimenting in the BushTender trial with auction systems (BushTender n.d., Stoneham *et al.* 2000). Game theory has provided the theoretical perspective. The practical experiences gained in the Conservation Reserve Program in the United States have been drawn on for operational aspects of the trial.

As part of the BushTender trial, NRE has developed a 'Biodiversity Benefits Index' that links conservation significance and vegetation quality to the cost of undertaking management actions necessary to maintain or enhance native vegetation. The relative conservation value of each site, the amount of habitat service being offered by each landholder and the cost of each bid has been combined into a Biodiversity Benefits Index using the following calculation:

$$\textbf{Biodiversity Benefits Index} = \textbf{Conservation Value Score} \times \frac{\textbf{Habitat Services Score}}{\textbf{Cost}}$$

The Conservation Value Score reflects the current significance of the vegetation, and is based on the type of vegetation and its conservation status and quality, presence of threatened species, and the position of the site in the broader landscape. The Habitat Services Score uses the current vegetation quality as a baseline and provides a measure of the extra value that the landholder has committed to provide through maintenance and/or improvement. It also incorporates an area multiplier. If the landholder commits to protecting an existing asset and as such forgoes a use right (eg. collecting firewood), this is treated as effectively providing a service. In other cases, active management (eg. weed control) that improves the quality of the site also qualifies as a service. Cost is the sum that the landholder has tendered.

The Biodiversity Benefits Index concept can be used in standard payment grant programs. It will help to focus effort onto high priority actions whenever landholders are paid for native vegetation management or other conservation actions.

4.2 Incorporating biodiversity standards into environmental management systems

Environmental management systems (EMS) provide information to farmers about the direction in which their management should change in order for them to be part of a recognised scheme. Performance standards characterise many EMS (Mech & Young 2001). Meeting performance standards would be an integral part of meeting the biodiversity management requirements of an EMS (Anderson *et al.* 2001). Scoring vegetation quality and identifying the increase in score that is likely to follow from adopting certain management actions is the basis for such a performance standard.

As yet there are few farms that have adopted EMS consistent with the ISO 14001 system. This is likely to change in the next few years. Biodiversity will be an integral part of such systems, if they are to meaningfully claim environmental credentials. NRE is trialing the application of a biodiversity module for EMS systems; Anderson *et al.* (2001) have proposed how this might be done.

Ultimately, EMS systems involve providing the information to consumers that allow them to focus their preferences on conservation values that are most significant, and for farmers to offer conservation services that meet those preferences. Consumers will be informed, for instance via labeling and certification, that a product has met the relevant standards. The producer will require detailed information from a biodiversity assessment, and management recommendations that capture the critical elements of native biodiversity on their property.

4.3 Setting priorities within voluntary programs

Information is increasingly available to landholders about the conservation significance of each biodiversity asset on their properties, and about how much change can be expected from a range of different management actions. This will increase the capacity of landholders undertaking voluntary effort to make judgements about where to put their resources. It is likely to lead to better outcomes for them and for the public good.

Such information is now being incorporated into extension programs such as Land for Wildlife and the advice given by officers of Trust for Nature and Catchment

Management Authorities. The complexity of biodiversity means that recognised experts will need to be involved at some point. While limited assessment can be undertaken by farmers without training, surveys will usually require experts who can compare a site against a benchmark and identify most if not all of the native and exotic grasses and forbs, and rank the effectiveness of a range of management actions for conserving biodiversity.

The emphasis is on identifying priority actions, rather than on 'anything you do is good for conservation'. This approach is likely to change the future interface between government and landholders

When decisions that directly or indirectly impact on the status of biodiversity on farms are being made privately, those providing the advice to decision-makers require access to high-level skills that can account for the impact on conservation as well as on farm profitability and cash flow.

Exploring how biodiversity priorities established at a landscape level are translated to the farm business level is an important question. It is particularly relevant where the farmer lacks information on the implications for the farm business of adopting technical options associated with biodiversity. Crosthwaite & Malcolm (2000) have recently explored the opportunities for farm businesses to maintain long-term viability while adopting conservation measures. The task here is to reveal the implications of adopting alternative conservation and investment options in terms of expected profitability, cash flow and risk. The outcome of such investigations is likely to influence the perceived opportunity cost of conserving biodiversity, and will thus influence the price at which the landholder is willing to reach agreement. It is likely, other things being equal, that landholders who feel more certain about the long-term future of the property will accept a lower price for conserving biodiversity.

5 Improvements in decision making at the macro-level

In the previous section, new mechanisms that directly influence landholder behaviour, and how improved biodiversity information is influencing them, were outlined. In this section, the integration of new information about biodiversity into decision-making at regional and catchment scales is outlined.

The information gathered from assessments of particular sites contributes to an overall picture of biodiversity management within a sub-catchment or larger unit. This information will be a key input into policy, specifically into the design of regulations, planning systems, incentives and revegetation programs. The net gain concepts, based on habitat hectares, can help set priorities under each approach, and can help to judge the effectiveness of different mechanisms for achieving policy outcomes.

An estimate of the current situation in Victoria is shown in Table 2. It is based on limited data, and it should be noted that the proposed accounting system is not yet in place.[5]

Table 2 Estimate of current progress in Victoria towards net gain - private land

Type of change in native vegetation	Estimated amount of change
Losses in extent	- 1000 habitat hectares/year
Losses in quality	- 4000 habitat hectares/year
Gains in extent	+ 100 habitat hectares/year
Gains in quality	+ 1500 habitat hectares/year
Total change in extent and quality	- 3400 habitat hectares/year

Source: NRE 2000

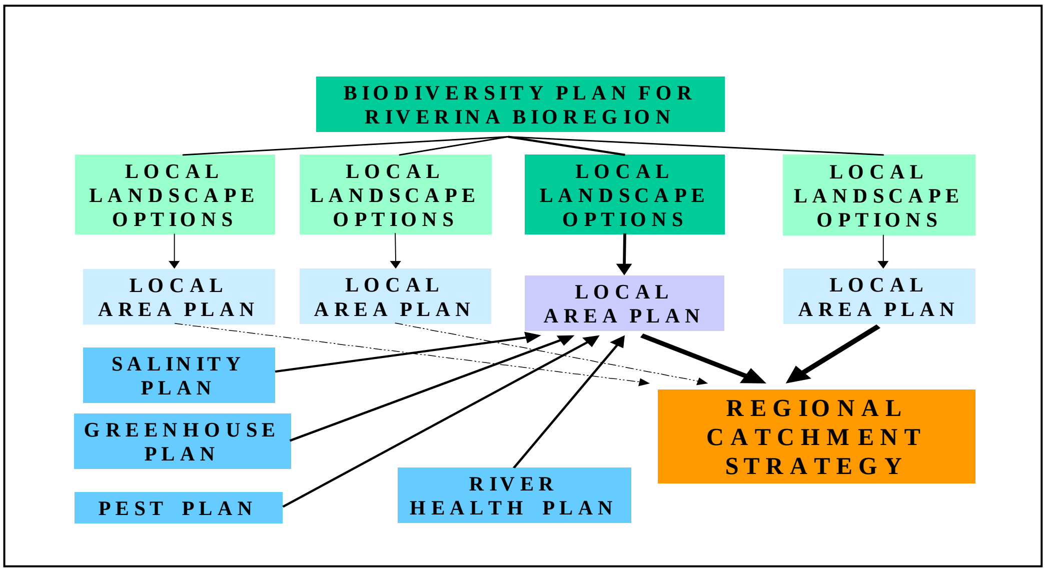
Major advances are expected in how biodiversity is 'integrated' within integrated catchment management. Biodiversity Action Planning is Victoria's way of getting biodiversity into integrated catchment management. The regional biodiversity strategy prepared under this planning process provides details and maps of the priority biodiversity assets within the area and the actions that are required to progress towards the statewide biodiversity goals. Detailed local landscape plans for conserving biodiversity within each bioregion will be developed over time. The strategy for each bioregion will have the following aims:

- model a regional approach, rather than a single-species approach, to biodiversity management,

[5] "It is based on mapped information of extent, estimations of quality statewide, improvements in quality due to incentive programs and gains in extent through revegetation for salinity and greenhouse." (NRE 2000)

- identify mechanisms for more efficiently conserving key biodiversity assets (threatened vegetation communities, threatened taxa, and important remnant habitats) in the study area, by focusing on the management of key threats across all land tenures,
- identify priorities for conservation and restoration of biodiversity, and
- present priorities in spatial forms so that they can be overlain with those of other environmental programs, such as salinity control and greenhouse amelioration, to encourage synergies.

The linkages for one region are shown below.



Bioregional planning provides a framework for thinking through how agricultural systems might be redesigned to deliver biodiversity benefits, as well as other public and private benefits. Such planning will identify priority assets to be protected, as well as areas where revegetation is required to expand or buffer areas of high conservation significance or important habitat for threatened species. Landscapes that are thus 'designed' for maximising biodiversity outcomes can be matched to scenarios that maximise agricultural production, water use or some other function.

In Victoria, a next step is to incorporate biodiversity information into the model, within the national Landmark project (Landmark n.d.), that is being built to study water use and revegetation scenarios in the Goulburn-Broken catchment. Economic modeling to determine the impacts of each scenario is to take place in a later phase of the project. Data about biodiversity that is about to be incorporated into this model includes:

- data layers for all ecological vegetation types,
- criteria relating to size, quality and connectivity of vegetation patches that reflect the requirements of selected threatened species,

Scenarios will be developed within the model that reflect the different extent to which biodiversity conservation requirements are achieved. It is expected that changes in habitat hectares under each scenario can be indicated for each sub-catchment or ecological vegetation class. As the machine rules for incorporating biodiversity into the model are relatively crude, changes may be manually made on maps produced under each scenario if sites that require protection or enhancement are missed.

6 Discussion and conclusion

Interpreting the biodiversity conservation problem as one of 'missing' information is a useful framing device to explore recent developments in tackling the problem. It fits with the emergence of information economics as a field of study. Two classes of information are relevant - about biodiversity and about mechanisms that can contribute to the achievement of policy goals.

The drive to fill information gaps has been driven by the development of a range of policy initiatives at all levels of Government. Biodiversity Action Planning has emerged in Victoria as a policy initiative that links the gathering of information about biodiversity conservation and the formulation of priorities within a given bioregion to other planning processes, for instance salinity, and to the mechanisms that might be used to deliver conservation outcomes.

Scoring native vegetation according to its quality, and identifying actions to improve quality, can be utilised in the design of new mechanisms such as auctions and environmental management systems. It can also contribute to the redesign of existing programs based on voluntary participation and existing grant programs.

The potential contribution of information economics in interpreting and posing solutions to biodiversity problems has only been touched on in this paper. Other areas requiring research include:

- the potentially negative implications of scoring vegetation and using particular mechanisms on landholder perceptions and behaviour. Undoubtedly, payments to farmers reduce the willingness of some landholders to act voluntarily, the issue is how significant such effects are in aggregate,
- the value of the information that integrated models reveal about biodiversity and the choices that are to be made weighed up against the downside of abstracting from the attributes of native vegetation and habitat by converting them into machine rules for the computer model,
- the information requirements of consumers and others in the marketing chain. The emphasis here has been on the 'supply-side',
- the mechanisms required to account for debits, or reduction in quality and quantity of native vegetation and species' habitat. It is all very well to claim incentives for credits, or improvements in quality and quantity. What is the quid pro quo for debits, and what limits to trade-offs are required given the irreversibility aspects of biodiversity?
- how changes in the provision of ecosystem services (e.g. carbon sequestration, clean water, and pollination) can be scored and incorporated into policy instruments.

Ultimately solving the biodiversity problem depends on whether Australia can develop institutions at regional, state and national levels that are capable of better reconciling economic, social and environmental objectives in a way that reflects the values of all Australians and provides for the needs of future generations. As Dovers (1999) and others state, we are currently a long way from that. Providing a rational foundation by overcoming information gaps about biodiversity and a set of mechanisms that make the problem tractable is of course an essential step. Rapid advances in information gathering and implementation of new mechanisms to conserve biodiversity are likely in the next few years.

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